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# Description

# Phase Change on Demand Integrated Pressure Pump and Power Plant

## BACKGROUND OF INVENTION

[0001] CROSS-REFERENCE TO RELATED DISCLOSURE

[0002] This disclosure claims priority to pending U.S. provisional patent application by the same inventors and the same title bearing serial number 60/319,591, filed October 2, 2002.

[0003] FIELD OF THE INVENTION

[0004] This invention relates to a portable pressure pump and integrated power supply that relies on high pressure generated by gases released during the phase change of a phase change material in a closed, constant volume container.

[0005] DESCRIPTION OF THE PRIOR ART

[0006] Published patent application WO 00/03758 in the name of SpectRx & Altea Technologies of Atlanta, Georgia, dis-

closes a pyrotechnic-based method for making an opening in skin for drug delivery.

[0007] Another patent application, number unknown, in the name of Carole Rossi, a researcher affiliated with LAAS-CNRS of Toulouse, France and the University of California at Berkeley, discloses a pyrotechnic method for drug delivery.

[0008] Many mechanical, pneumatic, and hydraulic devices are operated by gaseous or liquid pressure. Moreover, electricity-generating turbines are driven by fluids under pressure as well. Gaseous fluids under pressure occupy less space than gaseous fluids that are not under pressure, but it can be problematic in some applications if gaseous fluid under pressure must be maintained in a container or other pressure vessel for extended periods of time so that the gaseous fluid may be released when it is needed to operate a device or to generate electricity. It would be advantageous if there were a way to generate gaseous fluid under pressure on demand so that holding tanks or other pressure vessels having compressed gas therein could be eliminated.

[0009] However, in view of the prior art taken as a whole at the time the present invention was made, it was not obvious to those of ordinary skill how the identified need could be

fulfilled.

## SUMMARY OF INVENTION

[0010] The long-standing but heretofore unfulfilled need for a means for generating high pressure on demand is now met by a new, useful, and non-obvious invention.

[0011] The novel method for providing an energy reservoir of compressed fluid on demand includes the steps of positioning a phase change material in a constant volume container and activating a phase change in the phase change material. The pressure in the container thus increases in accordance with Boyle's law.

[0012] A method for harnessing the energy in compressed fluid to do usable work includes the steps of providing an energy reservoir of compressed fluid on demand by activating a phase change in a phase change material positioned in a constant volume container and connecting a pressure-driven load in fluid communication with the energy reservoir of compressed fluid. The pressure-driven load may be a turbine adapted to generate electrical power, a piezo-chamber adapted to generate electrical power, a pump, or the like.

[0013] The pressure-driven load is positioned between the energy reservoir of compressed fluid and a high pressure

storage tank. More particularly, the energy reservoir of compressed fluid is in fluid communication with an input of the pressure driven load and the high pressure storage tank is in fluid communication with an output of the pressure-driven load.

[0014] A pneumatic or hydraulic circuit may also be positioned in fluid communication between the energy reservoir of compressed fluid and said high pressure storage tank. A mechanical, fluidic, or other pressure-driven load may be coupled to an output of said pneumatic or hydraulic circuit.

[0015] The invention further includes a novel microbattery that includes a plurality of layers of elements that interact with one another to produce an electrical current. A plurality of propellant members, each of which is formed of a phase-change material, is mounted to one of said layers of elements. The microbattery further includes an initiator means that may take the form of a plurality of conductors, each conductor of said plurality of conductors providing electrical communication between a preselected propellant member of said plurality of propellant members and said initiator means.

[0016] Another layer provides a pressure cell that defines a

closed volume for housing the plurality of propellant members. A fluidic oscillator is mounted on the pressure cell and a flexible diaphragm is mounted to the fluidic oscillator. The flexible diaphragm is adapted to oscillate as the fluid oscillator alternately directs fluid to opposite sides of the flexible diaphragm.

[0017] A magnetic core is mounted to the flexible diaphragm. A cap layer is mounted in surmounting relation to the flexible diaphragm. A coil is mounted to the cap layer and is adapted to receive the magnetic core.

[0018] A preselected propellant is activated by the initiator means, resulting in an explosion of the preselected propellant that increases pressure within the pressure cell. The pressure is harnessed to drive the fluidic oscillator and the fluidic oscillator causes flow of a preselected fluid to alternately flow to opposite sides of said flexible diaphragm so that the flexible diaphragm oscillates and thereby causes back-and-forth motion of the magnetic core relative to the coil. The relative motion between the magnetic core and the coil produces alternating current.

[0019] It is therefore understood that a primary object of the invention is to provide a portable pressure pump and an integrated power supply that relies on high pressure that is

generated on demand to obviate any need for storing high pressure gases or liquids. The power is optionally incorporated. The pump can stand alone.

[0020] A more specific object is to generate usable high pressure on demand by activating a phase change material that is housed within a closed container so that the pressure within said container is increased.

[0021] Another object is to disclose a microbattery construction made possible by the use of a phase change material for producing high pressure gases on demand.

[0022] These and other objects will become apparent as this disclosure proceeds. The invention includes the features of construction, arrangement of parts, and combination of elements set forth herein, and the scope of the invention is set forth in the claims appended hereto.

## Brief Description of Drawings

[0023] For a fuller understanding of the nature and objects of the invention, reference should be made to the following detailed description, taken in connection with the accompanying drawings, in which:

[0024] FIG. 1 is a longitudinal sectional view of a typical disposable high-pressure pump of the prior art;

[0025] FIG. 2 is a diagrammatic representation of compressed-air

energy storage plant;

[0026] FIG. 3 is a diagrammatic representation of a combined electrical, pneumatic, and hydraulic power plant; and

[0027] FIG. 4 is a perspective view of an AC flow, pressure on demand microbattery.

[0028] FIG. 5 is a diagrammatic view of an application of the invention.

[0029] FIG. 6 is a diagrammatic view of an addressable patterned grid.

## Detailed Description

[0030] An integrated pump includes a pressure source and an integrated particulate filter. It pumps clean gas or liquid into separation systems such as chromatographic columns. The material used for actuation is any material that transitions through a phase change in a confined, constant volume, resulting in a pressure increase in accordance with Boyle's law. More particularly, the material may be any reactive material such as pyrotechnic powders, plastic based explosives, binary reactant explosives/propellants, hypergolic reactant propellants, catalytic reactants, combustion reactants or other phase change material.

[0031] The phase change material may be patterned into the in-

tegrated device. Thus it is understood that the pump may be programmable for sequential actuation.

[0032] The novel pump also yields an alternative power supply technology. The pressure generated is used to activate an energy converter such as a high pressure turbine, a piezoelectric material, or an elastic strain material (such as a spring, for example) to convert the energy stored in the compressed fluid. A hybrid actuation system of electrical energy, pneumatic and hydraulic power is thereby created.

[0033] A pressure driven fluid pump and pressure driven power supply (either electrical, pneumatic or hydraulic) is reliant upon the pressure developed during a phase change of state of a preselected phase change material.

[0034] The phase change enables a volume expansion within a constrained vessel creating a desired high pressure that provides the motive force for fluid transfer, actuation and stored energy for subsequent energy conversion. Significantly, the high pressure is not generated until it is needed, thereby eliminating the prior art need to have gases or liquids maintained in pressure vessels over long periods of time until such pressure is needed.

[0035] Fig. 1 depicts a single use, disposable high-pressure

pump 10 of the prior art. Blind bore 12 is formed in pressure vessel 14. Blind bore 12 is internally threaded as at 16 to receive any external capillary tubing 18. Flow regulator 20 performs the function its name expresses. A solid plug 22 having a porous center 23 is positioned in closely spaced relation to flow regulator 20 and provides a closure means for cavity 24 which contains a homogenous charge. In the alternative, means 26 may be provided to pattern the charge for sequential action. Photopatterning (or other screen patterning) is possible to create the pattern.

[0036] The material may be patterned (*e.g.* using photoreaction polymer-based explosives/propellants (such as PBX)) to enable programmable pressure delivery or a train of actuators for sequential actuation either to maintain a desired pressure over time or actuate over time as part of a process activity.

[0037] The filter is integral to the operation of the pump because clean, particulate-free fluid is required in intended applications such as high pressure chromatographic systems.

[0038] Methods for actuating the phase change material include thermal, electrical, mechanical impact or a hybrid (of electrical/mechanical) such as piezoelectric.

[0039] As indicated in Fig. 2, the pressure generated may also be used as an energy reservoir of compressed gas or liquid which is subsequently expanded into a turbine, a piezo-chamber, or other means for converting compressed fluid into electrical power. The compressed liquid or gaseous fluid energy storage may also have utility in delivering pneumatic, mechanical, or hydraulic power for process actuation.

[0040] More particularly, system 30 includes a low pressure storage tank 32 in fluid communication with pump or turbine 34 disposed in driving relation to a motor or generator 36. Transformer 38 connects the output thereof to electrical loads in a well-known way. In this way, the pressure provided by the phase change is harnessed for electrical power.

[0041] Pump or turbine 34 is also in fluid communication with high-pressure reservoir 40. Reservoir 40 is deemed to be a high pressure reservoir because the pressure therein is greater than the pressure in reservoir 32. This pressure may be used on demand by any pressure-driven load.

[0042] Fig. 3 depicts a system 50 including a combination of electrical power generation and pneumatic and hydraulic force generation. The combined electrical, pneumatic, hy-

draulic power plant may be either single use (disposable) or rechargeable.

[0043] More particularly, the structure of system 50 is the same as that of system 30 of Fig. 2, but with the addition of a pair of branches 52, 54 that provide fluid communication between pump or turbine 34 and pneumatic circuit 56 or hydraulic circuit 58, respectively, or both. Pneumatic circuit 56 is positioned in driving relation to mechanical loads, fluidic loads, or other pressure-driven loads. Hydraulic circuit 58 is also positioned in driving relation to mechanical loads, fluidic loads, or other pressure-driven loads.

[0044] Fig. 4 depicts an AC flow, pressure on demand, microbattery 60. Current is generated by oscillation of magnetic core 62 in and out of coil 64. Fluidic oscillator 66 alternates the flow of fluid into each side of flexible diaphragm 68 and moves core 62 back and forth, said magnetic core 62 being mounted on said flexible diagram 68 as depicted. Each explosive charge is actuated by a substrate 70-mounted conductor 72 that also acts as an initiator. Microbattery 60 further includes cap layer 74, within which said coil 64 is formed, pressure cell 76, propellant mold and bond layer 78, and a plurality of propellant or

explosive dots 80 formed of a phase change material.

[0045] In all embodiments, the device may be large in scale. However, the preferred and most likely to use embodiment includes the disclosed pumps and power plants in small-scale packages.

[0046] It will thus be seen that the objects set forth above, and those made apparent from the foregoing description, are efficiently attained and since certain changes may be made in the above construction without departing from the scope of the invention, it is intended that all matters contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

[0047] It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

[0048] Now that the invention has been described,